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THE LEARNING RESEARCH AND DEVELOPMENT CENTER'S COMPUTER ASSISTED LABORATORY.

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THIS PAPER DESCRIBES THE OPERATION AND PLANNED APPLICATIONS OF A COMPUTER ASSISTED LABORATORY FOR SOCIAL SCIENCE RESEARCH. THE LAB CENTERS AROUND AN 8K PDP-7 COMPUTER AND ITS SPECIAL PERIPHERAL EQUIPMENT. SPECIAL DEVICES INCLUDE RANDOM ACCESS AUDIO AND VIDEO, GRAPHICAL INPUT, AND TOUCH-SENSITIVE AND BLOCK-MANIPULATION INPUTS. THE SYSTEM MAY BE USED FOR PRESENTING INSTRUCTIONAL MATERIAL OF FOR CONDUCTING PSYCHOLOGICAL EXPERIMENTS. ILLUSTRATIONS ARE PROVIDED. REPRINTED FROM "DECUS PROCEEDINGS," VOLUME 5, NUMBER 2. (MS)

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THE LEARNING RESEARCH AND DEVELOPMENT CENTER'S COMPUTER-ASSISTED LABORATORY

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THE LEARNING RESEARCH AND DEVELOPMENT CENTER'S COMPUTER ASSISTED LABORATORY

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THE LEARNING RESEARCH AND DEVELOPMENT CENTER'S COMPUTER ASSISTED LABORATORY *

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ABSTRACT

This paper describes the operation and planned applications of a computer-assisted laboratory for social science research. The laboratory centers around an 8K PDP-7 and its special peripheral equipment, with most of the system already in operation. Special devices include random-access audio and video, graphical input, touch-sensitive and block-manipulation inputs. The control programs for these devices are incorporated in an executive system which permits simultaneous operation of six student stations. The system may be used for presenting instructional material or for conducting psychological experiments.

In April of 1964, the Cooperative Research Branch of the United States Office of Education established a research and development center at the University of Pittsburgh as part of the Office of Education's program designed to concentrate major effort in various areas in education. The Center at the University of Pittsburgh, called the Learning Research and Development Center (LRDC), directs its activities to design and development of instructional practices on the basis of experimental research on learning.

One activity has been construction of a computer-assisted laboratory as a first step of a project on computer-assisted instruction. The Computer-Assisted Instruction Project has two principal objectives which guide the scope of the effort undertaken within this group. The first objective is to provide those facilities and services needed to support the research and development effort of experimental psychologists and others in the field of instructional technology. The facilities include apparatus and controls used in learning experiments which use computer-related equipment. The group provides engineering and programming assistance in design and conduct of experiments. This service, primarily for the Center staff, may be used by other faculty members.

The second objective of this group is to conduct experimental work in the development of computer-based instructional systems. Examples of such work include the development of supervisory programs for controlling many independently operating stations; the development of languages that educators can use for subject matter programs on the computer; and the development of student stations that will provide a high degree of interaction between the student and the subject matter.

HARDWARE

The main piece of hardware involved in this project is a Digital Equipment Corporation PDP-7 computer, installed in mid-June of this year. In addition to the standard PDP-7 configuration, this computer has 8,192 words of core memory, 16 levels of automatic priority interrupts, the extended arithmetic element, 100 card-per-minute reader, variable time clock with speeds up to 1000 cycles per second, 2 output relay buffers and terminals for connecting student devices to the computer. The core memory will soon be increased to 16,384 words, with the additional 8,192 already on order. It is anticipated that magnetic drum storage will soon be added to the system as well.

In addition to the computer room, shop area, and an auxiliary equipment room, there are eight separate laboratory areas which average about 180 square feet. The labs range in size from 140 square feet to 285 square feet, with two of the larger labs having observation areas separated from the lab room by one-way glass.

Electrical ducts connect each laboratory area to the computer room. This allows a great deal of flexibility in assigning display and response equipment to the student station. The most basic device is the keyboard, which is

* The research and development reported herein was performed pursuant to a contract with the United States Office of Education, Department of Health, Education, and Welfare under the provisions of the Cooperative Research Program.

a modified Type 33 Teletype keyboard. Because no printer is associated with the keyboard, this function is usually served by an oscilloscope screen (a Tektronix RM 564 connected with a Type 34 interface). This scope can be operated in stored mode in which information on the screen is preserved and does not have to be refreshed. When the scope is in dynamic mode (selected under computer control) it may be used with a light pen.

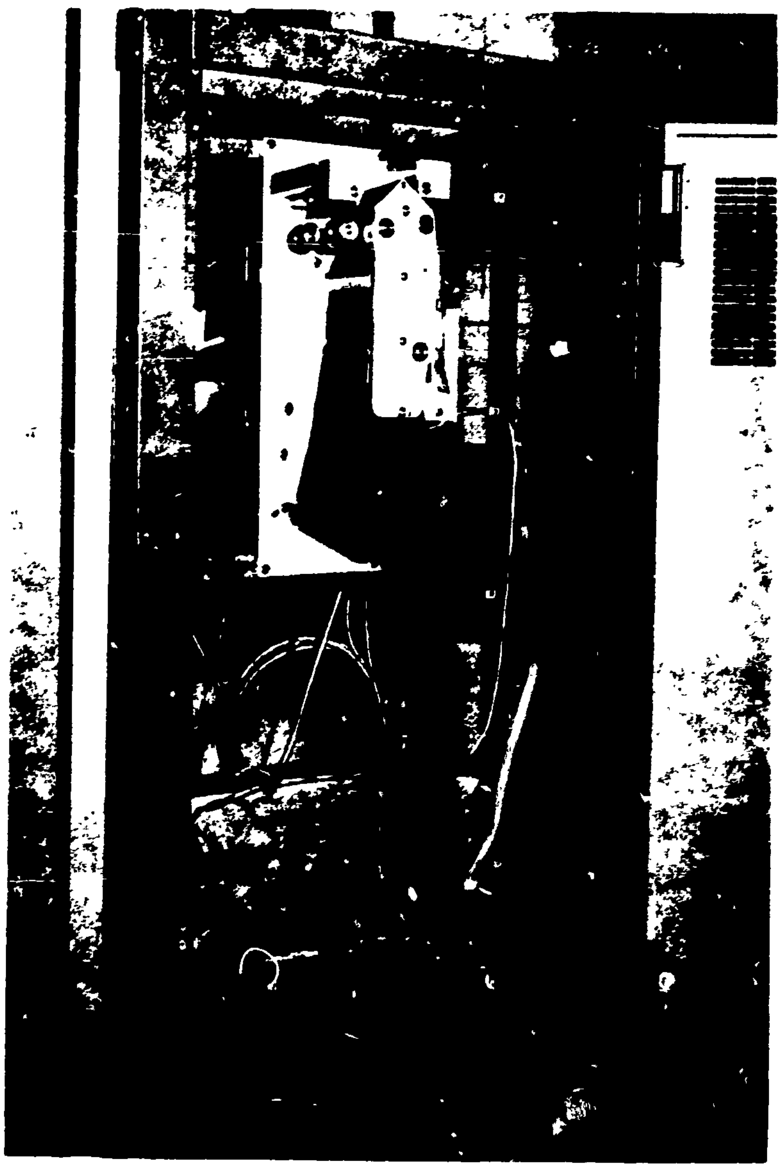

Figure 1 The Random Access Audio-Unit Built by Westinghouse

Another basic device is the audio speaker (or head set). Audio information is stored on loops of 6-inch wide magnetic tape. Each loop has 128 tracks, with 16 play and record heads each servicing 8 tracks. The size of the loop is variable, but at present each holds 1,024 seconds of information with each 1-second block individually addressable. Although it is not a standard item, there may also be a microphone at the student station so that he can record on certain areas of the tape reserved for this purpose (through software). Basic equipment for a student station consists of a keyboard, a cathode ray tube with light pen, and an audio speaker or head set (see Figure 2).

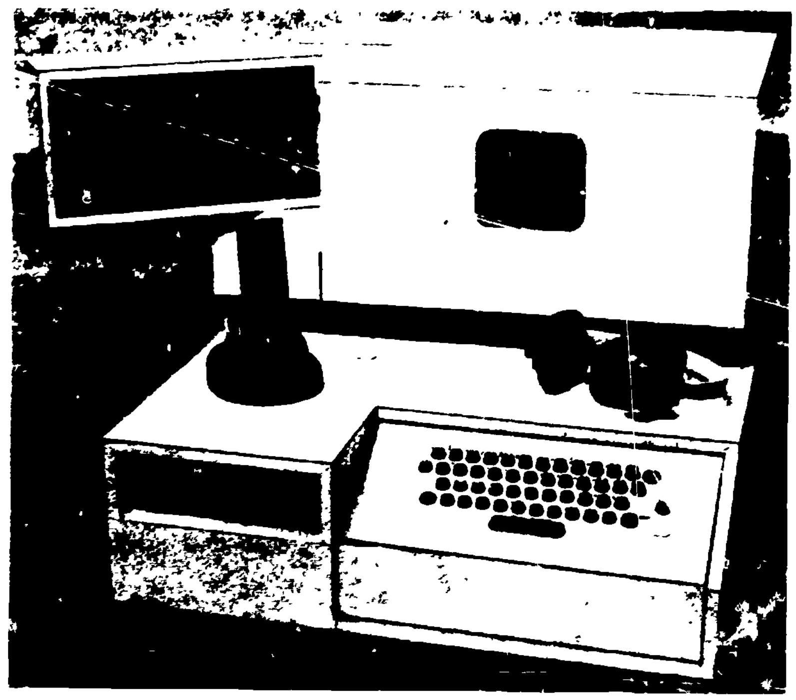

Figure 2 The Basic Student Station with Keyboard, Scope, Speaker, Earphones, and Microphone

In addition to the basic student station devices, a number of special devices, some experimental, exists. One special device already in operation is the "touch-sensitive display" (Figure 3). A random access slide projector is focused on a back lighted screen which displays the information for the student. Many fine wires within the screen allow detection of an object, such as a finger or pointer, striking the screen. Detection of such a response also specifies the location of the response upon the screen. Since the projector and the screen are both under computer control, the presentation of visual stimuli may be sequenced according to the position of the preceding response(s).

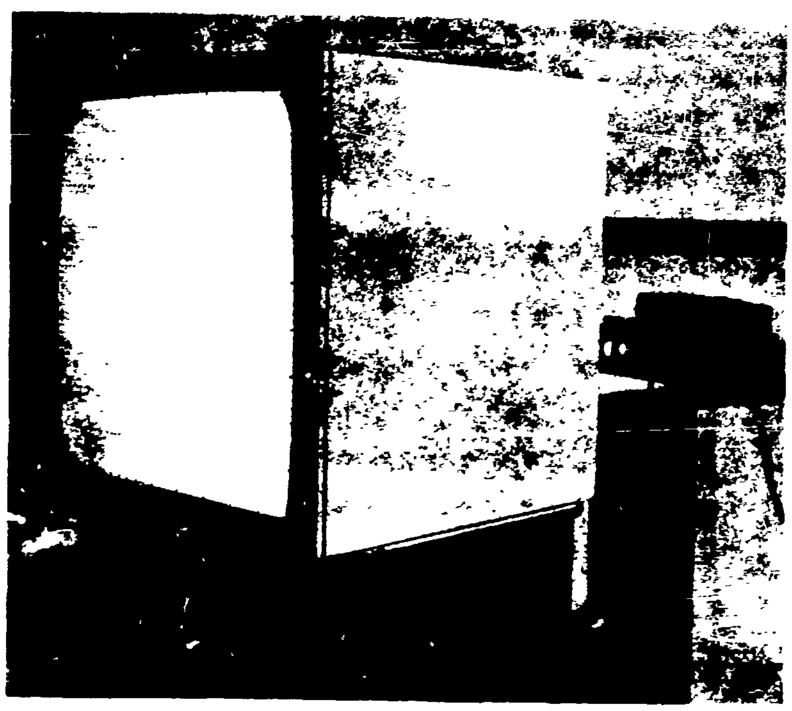

Figure 3 The Touch Sensitive Display with Random Access Slide Projector

Other devices under development include graphic tablets like the "RAND tablet" and "manipulation boards." The graphic tablet is a device through which a student may input graphical information directly to the computer with an electronic pencil (Figure 4). The tablet, used in conjunction with appropriate diagnostic routines, permits the teaching of printing and drafting, to name only one example, in a manner which allows easy detection of student errors.

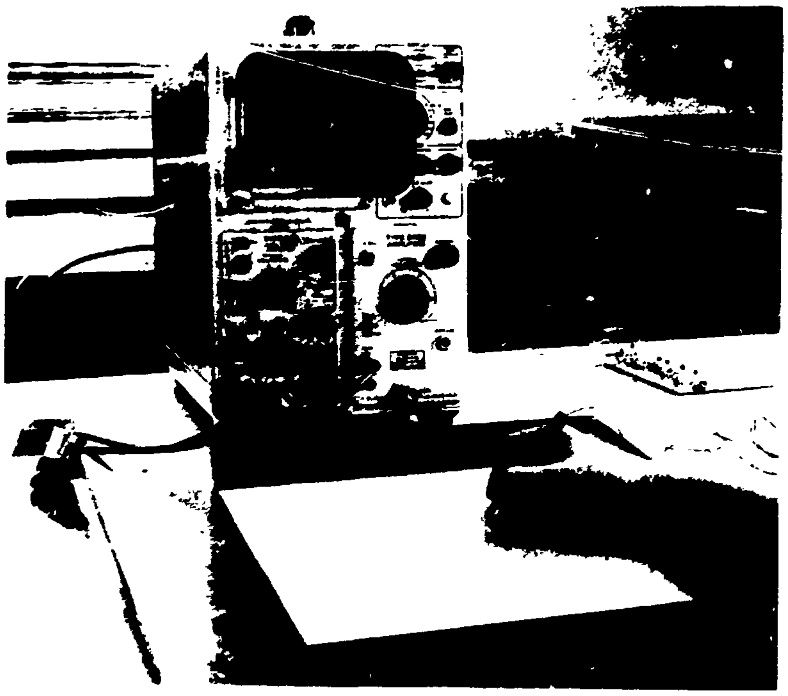

Figure 4 The Graphical Input Surface

At the RAND Corporation, the graphic input tablet is used for debugging programs. A scope displays the contents of several standard locations plus some memory location. The programmer can search memory upward or downward by pointing the electronic pencil at the appropriate spot. He can change the contents of a displayed memory location by merely writing over the display with the electronic pencil.

Figure 5 shows the manipulation board which detects the placement of objects on its surface and relays the corresponding bit pattern to the computer. The problem here is very similar to that of the RAND tablet in that a bit pattern must be recognized. However, in this case, the set of objects such as blocks representing different number quantities, can be restricted to those easily identifiable. With such a restriction, the set of objects can be identified both as to item and location upon the board. This device should be particularly effective in working with young children, or the mentally retarded, since it puts very little demand on the student insofar as the structure of the response is concerned.

A device for magnetic storage of video information is planned for the near future which will permit storage of approximately 500 pictures combining video camera or computer-plotted output. The selection of pictures will be under computer control and additional points may be plotted on the selected picture at any time. This system will also permit the use of a light pen.

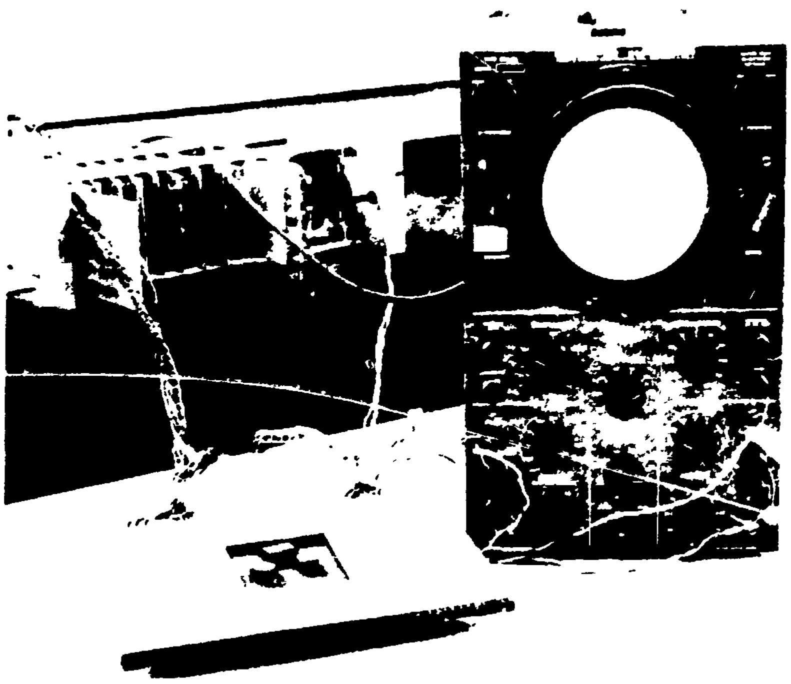

Figure 5 A Small Developmental Model of the Manipulation Board

SOFTWARE

The present software system, still in the final debugging state, consists of a set of control programs for each of the various devices as well as an executive system to control the sequencing of jobs, timing, memory allocation, etc.

All teaching or experimental programs being contemplated are of a type usually waiting for a student response or for some time delay to run out. When this happens, the program returns control to the scheduler and some other job is initiated. In general, this system is capable of servicing six devices of each type, although at present only one of each is in use.

Most of the 16 priority levels are already used by the system. The 60 cycle and 1000 cycle clocks each use 2 levels. Keyboards, light pens, touch-sensitive displays, microphones, and audio tapes also require priority levels based upon the speed of the response they demand. In addition, the executive routine responds to a priority level which may be activated through software.

This interrupt, which has the lowest priority level, is set whenever an interrupt signals the end of some job's suspension. Thus, when all other interrupts have been processed, the scheduler regains control and can reinitiate this job.

Programming of learning experiments, teaching routines, etc., can be accomplished only by machine language at present. A large part of the coding would, of course, be in the form of subroutine calling sequences which reference the control programs. This type of programming may be more difficult and time consuming, but it also offers a maximum in flexibility.

One major goal of the Computer-Assisted Instruction Project is the implementation of a language which educators can easily use for programming subject matter on the computer. Although the final goal in this area is a compiler which accepts lessons written in some behaviorally oriented language and translates them into the proper codes, several steps are involved. The first, and probably the most important, is the definition of terms which denote particular instructional subsequences, etc. From this foundation, one can proceed until a final compiler is defined and operating.

INDIVIDUALIZED INSTRUCTION

A project which is planned to eventually merge with the Computer-Assisted Laboratory is now being carried out in a suburban Pittsburgh elementary school. In this school, students are allowed to progress at their own rate through curricula in mathematics, reading and science, as they might in a computer-assisted classroom. Each unit of instruction is composed of skills which must be mastered with appropriate instructional materials and progress and quality control tests provided for each skill to be learned. There is a considerable library of instructional sequences and relevant information provided by the materials for a particular skill, and the teacher must prescribe those materials which she feels are most appropriate. It is clear that a curriculum of this type lends itself well to computer instruction, the major difficulty being simulation of the teacher's decision process.

LEARNING EXPERIMENTS

The development of a library of programs relevant to the running of learning experiments is less structured. There are certain basic paradigms which provide a basis for such a library, but the need is for more flexibility, in addition to implementing the old routines.

There are two major objectives in the learning experiment area: experimental design and real-time data analysis. In the design and control of learning experiments, programs would assign subjects to groups on the basis of certain control variables; they would monitor information such as "anxiety level," for example, and modify it if necessary; and they would equate the subject's performance on a certain task prior to the application of the experimental treatment by the assignment of appropriate training or by statistical adjustment. These programs would perform those tasks usually requiring lengthy subject selection prior to the experiment or the conduct of preliminary base-line pilot studies.

Closely related to these programs are programs for real-time data analysis which provide data for the control and design section. This would permit use of complex criterion measures in equating the performance of subjects, to mention only one example. This type of data analysis would be especially helpful in a pilot study, since one could start out with a large number of variables and as the analysis indicated, discard those obviously relevant or obviously irrelevant, and concentrate on the more marginal variables.

Eventually the system might assist in the selection of the variables of interest and the assignment of the experimental treatments. The system would also analyze the data, and terminate the experiment when sufficient precision was attained.